Enabling Effective Decisions
(CROMDI: Center for the Representation of Multi-Dimensional Information)
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Perhaps one of the most challenging and long-standing problems confronting decision makers of all types is the necessity of assimilating large amounts of data, converting it to meaningful, useful information, then selecting an appropriate course of action based on that information.

In some cases, such as the health care environment, this can involve literally life-or-death decisions. In industry settings, decisions may not affect lives but can mean the difference between millions of dollars in profit or loss.

One approach to solving these problems may come out of one of the Centers of Excellence at the University of Utah known as CROMDI (Center for the Representation of Multi-Dimensional Information).

“For the past 10 years, everyone has been complaining about how to manage information overload," says Julio Bermudez, an associate professor of architecture at the University of Utah and a member of CROMDI. If you look at the daily lives of people, both at work and in personal activities, they are constantly dealing with lots of information and having to make quick decisions.”

INTUITIVE INFORMATION

The purpose of the interdisciplinary research at the Center is to create solutions to the way large data sets are represented in space, time, color, sound, etc. so that they can be intuitively interpreted and comprehended in real time by any person. They specialize in studying problems where decision making depends on making sense of information that is intrinsically non-spatial, non-dimensional, and abstract.

For example, an analyst or executive who wanted to understand patterns and trends in a financial market that could form the basis for intelligent decision-making would want to be aware of changes in a stock or stock portfolio value, historically and on a moment-by-moment basis. It would also be necessary to see what was happening to the prices of stocks of similar companies in the same industry sector, including immediate and long-term price changes for each stock, the volume of trading in the relevant sector, and the market shares of the stock in question in relation to its competitors.

That is clearly more information than one person could hold in mind at one time by any conventional means. CROMDI has created a 3D audio-visualization technology called *IntuInfo* to facilitate the rapid and accurate analysis of such large and quickly-changing data sets. Using a central set of interface "tools," the methodology can be applied to data representation problems in such fields as finance, medicine, entertainment, process and traffic control, corporate management and decision-making.

STRENGTH THROUGH DIVERSITY

A key to the success of these projects has been the interdisciplinary team brought together by CROMDI director Dr. Stefano Foresti, a mathematician by training. The Center has collaborators in the Departments of Architecture, Art, Communication,. Computer Science, Mathematics, Music, Psychology, Medicine, Anesthesia, Bioengineering and Finance.

CROMDI affiliate Jim Agutter, a research assistant professor in the School of Architecture, explains how the collaboration works:

"We select a data challenge in a field such as finance or anesthesia. Julio (Bermudez) and I work on the design of the interface, then the bioengineers help define the problem and look at the data sets that we need to manage to develop the appropriate application.

"Next, the computer scientists help us execute and build the design, and cognitive psychologists help us to understand what the end user is going to want and need to see. Then we go and do actual simulation studies to prove the efficacy of the model. It takes this full cycle to be able to say that the resulting model is the best we can come up with."

Foresti adds, "An essential aspect of the *IntuInfo* interface is the fact that it relies on innate human intuition of 3-dimensional geometry and visual-auditory cues that are common to all people because of the way that the human brain and body processes information about the real world around us.

"Users are intuitively able to detect and react to changes in data over time through changes in geometry, position, size, shape, texture, color and opacity, sounds, and other perceptions. As a result, users react much faster and more accurately to data and rely less on cognitively having to "think" about the information being displayed."

INTUITIVE OBJECTS

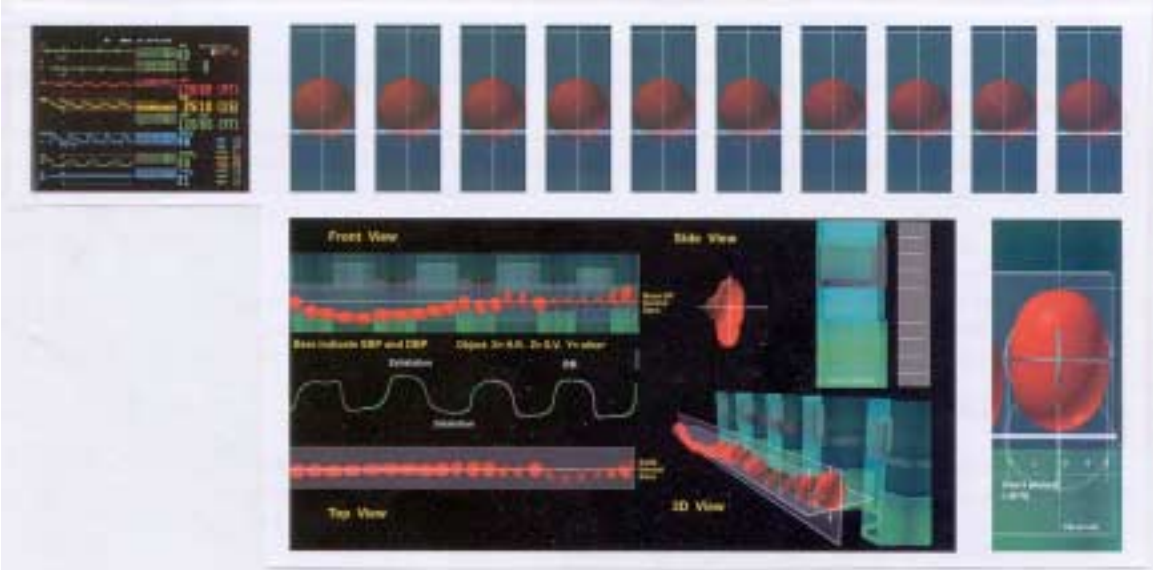
Foresti explains how this research is different from the work of the SCI Group run by Dr. Chris Johnson, also at the Center for High Performance Computing at the "U." "What we do is distinct from scientific visualization, because we are not representing objects that already have a physical form and a shape. We create a completely new representation. For instance, there is no implicit way of representing heart rate or the momentum of stock market prices."

"We work at creating what we call intuitive objects," adds Bermudez. "These objects follow a set of rules we have derived from psychology and architecture, objects people associate with some real world event. These objects are things that you have an association with, just due to the fact that you are alive and have gone through childhood. For example, you might see a drawbridge that is too high, and be able to infer that cardiac output is low and heart rate is too fast."

Bermudez recently had the opportunity to test the interface at a conference. "People with no background in anesthesiology were able to quickly pick up where and when a patient had heart problems," he said. "They weren't able to make a diagnosis, but they could see the problems."

DEMOCRATIZING KNOWLEDGE

Foresti sees broad, essential social implications in the work being done by CROMDI. "This represents a democratization of knowledge and information," he says, "because it has the potential to allow anyone with minimal perceptive skill to understand complex information."



This 3-D view provides a comprehensive, integrated and interactive view of nine physiological variables. The red object in the center of the 3D view, which visually represents a beating heart, expands and contracts with each heartbeat. Its height is proportional to the heart's stroke volume, its width to heart rate.

APPLICATION OF CROMDI TECHNOLOGY IN ANESTHESIOLOGY

In evaluating potential demonstration projects for the IntuInfo interface, CROMDI's researchers sought a real-world case where proper information interpretation was critical. They ultimately chose anesthesiology, in which doctors face unexpected incidents during administration of 20 percent of all anesthetics. One in four of these incidents represent critical events posing significant danger to patients. The stress of the environment is compounded by the fact that more than 30 variables need to be continually monitored, mentally correlated and integrated.

CROMDI's medical team, led by Dr. Dwayne Westenskow, developed a working prototype for detecting, diagnosing and treating anesthesia-related critical events. The prototype display, which reduces recognition times significantly in critical events, consists of cardiac objects and a pulmonary "curtain," is shown above, next to a figure of a traditional waveform display.

The gridframe shows the expected normal values for stroke volume and heart rate. The position of this object on the page is proportional to the patient's mean blood pressure. The ends of the bar drawn vertically through the center of the heart icon show systolic and diastolic blood pressure.

The colored background shows inspired and expired gases. The height of the "curtain" is proportional to tidal volume. The width of each fold is proportional to respiratory rate. The blue, green and yellow colors show the concentrations of respiratory gases (nitrous oxide, oxygen and carbon dioxide). Time moves from right to left with present conditions at the "front" or right edge of the view. Past states remain to permit a 'historical" view of the data.

In actual use, this prototype display showed a statistically significant decrease in detection time for several critical parameters. iQ